THE HURRICANE SEASON OF 1967

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1. GENERAL SUMMARY

The 1967 hurricane season in the North Atlantic was singular for a number of reasons. The first named tropical cyclone, Arlene, developed late in the season on August 28 and reached hurricane intensity on September 2. There have been only seven seasons, 1897, 1905, 1914, 1920, 1923, 1925, and 1941, that began later in the summer. None of these produced more than seven tropical storms or hurricanes. The total of eight in 1967 establishes a record for such a late-starting season.

The late season is explained mainly by the general broad-scale circulation features at middle and low latitudes. According to Wagner [1], higher than normal heights at 700 mb. became established across the central Atlantic Ocean during June. The pattern of height anomalies agreed very well to Ballenzweig's [2] composite chart for maximum tropical cyclone incidence for North America. While there were no named cyclones during June, the month was active since there were four well-defined tropical depressions [8]. The strongest of these was the one which entered the Carolinas on the 17th.

Dickson's [3] analyses for July indicate a reversal of June's long wave distribution and his 700-mb. anomaly chart is not too unlike Ballenzweig's composite for minimum cyclone activity. Consistent with these data, there were no depressions in July. Indeed, satellite pictures were practically void of disturbances or cloud features which are usually antecedent to cyclone development.

This unfavorable pattern for tropical cyclone development persisted through August. The feature is revealed in the similarity of the departures from normal charts (700 mb.) for July and August. In discussing the circulation for August, Posey [4] states that the long wave pattern changed very little during the 2 months and that the positive anomaly over the western Atlantic continued in the same lacation. Dunn and Miller [5] have shown that "persistent departures from normal in either position or strength (Azores-Bermuda High) have a profound influence on hurricane frequency. . . . " The 700-mb. positive anomaly in the western Atlantic was consistent with a pronounced westward shift of the surface Azores-Bermuda High; both are considered unfavorable for genesis.

The persistence of circulation features from month to month is a very interesting field and is watched very closely by operational forecasters. Namias and O'Conner [2] have suggested that too much persistence on a daily basis results in a fewer than normal shearing troughs. This, of course, inhibits lower tropospheric circulations, or positive vorticity maxima, at low latitudes, which are often the synoptic forerunners of development. In summary, it is thought that the statistically unfavorable positions and the persistence of monthly and daily circulation features accounted for the lack of tropical cyclone development in July and August.

Beulah, Chloe, and Doria quickly made up for lost climatological time. All three, with hurricane force intensity, were on the same weather map for portions of 5 days. On September 16, a noteworthy first in satellite photography occurred when all three were photographed on the same orbital pass by ESSA 2 [9]. Figure 1 is a composite of ESSA 2 photographs taken on September 17, showing the three simultaneous storms. At that time Beulah and Chloe were intense hurricanes while Doria, on the North Carolina coast, was barely of storm intensity. Beulah and Doria were the only two that affected the United States. Beulah was a great hurricane and should be added to the list compiled by Kraft [6]. This totals 12 great hurricanes since 1955.

Hurricane days numbered 44, which is about 10 more than the yearly average established during the past 14 yr. (table 1). The tracks of the eight named tropical cyclones

TABLE 1.—*Hurricane days, 1954–1967*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1954						1		5	8	16		1	31
1955	4							22	28	2			56
1956							1	9	2		3		15
1957						3			19				22
1958								14	16	5			35
1959						1	2		10	11			24
1960							4	2	13				19
1961							4		*35	9	1		49
1962								1		10			11
1963								11	7	23			41
1964								7	33	6			46
1965								6	*21	3			30
1966						7	8	9	11	10	5		50
1967									*33	11			44
Total	4					12	19	86	236	106	9	1	473

*If two hurricanes are in existence on 1 day, this is counted as 2 hurricane days.

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[2] Private communication between J. Namias and G. E. Dunn.

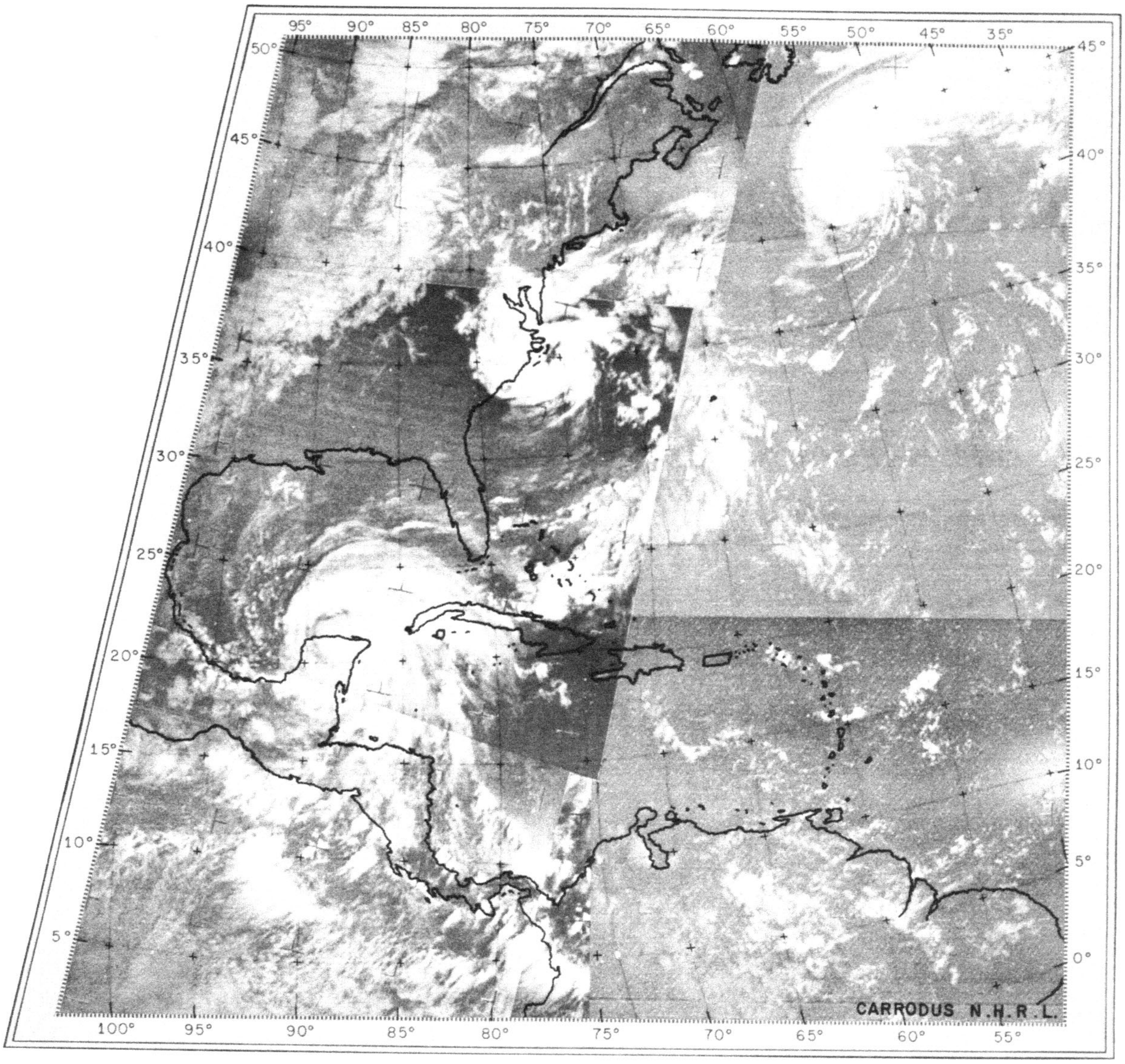

FIGURE 1.—Composite of ESSA 2 photographs, September 17, 1967, showing Beulah (over the northern Yucatan Peninsula), Doria (over the North Carolina coast), and Chloe (southeast of Newfoundland).

TABLE 2.—*Estimated damages and casualties, hurricane season 1967*

Date	Storm	United States		Other areas		
		Deaths	Damages		Deaths	Damages
June 14–18	Tropical depression	0	*$15,000		0	0
Aug. 28–Sept. 4	Hurricane Arlene	0	0		0	0
Sept. 5–22	Hurricane Beulah	Texas 15	200,000,000	Martinique	15	$4,500,000
				St. Vincent	2	minor
				Dominica	0	minor
				St. Lucia	0	3,000,000
				Puerto Rico	1	**150,000
				Dominican Republic	2	***unknown
				Haiti	unknown	***unknown
				Cozumel Island	0	***unknown
				Yucatan	5	***unknown
				Northern Mexico	19	***unknown
Sept. 5–21	Hurricane Chloe	0	0		3	0
Sept. 7–19	Hurricane Doria	3	minor		0	0
Sept. 26–Oct. 1	Tropical storm Edith	0	0		0	minor
Oct. 1–4	Hurricane Fern	0	0	Tampico	3	minor
Oct. 5–8	Tropical storm Ginger	0	0		0	0
Oct. 19–Nov. 1	Hurricane Heidi	0	0		0	0
Totals	2 tropical storms 6 hurricanes 1 tropical depression	18	$200,000,000		50	$7,650,000

*Not included in total since beneficial rains and sand deposition offset entire amount.
**Some beneficial rains.
***Considerable damage to crops and houses but no dollar estimate available.

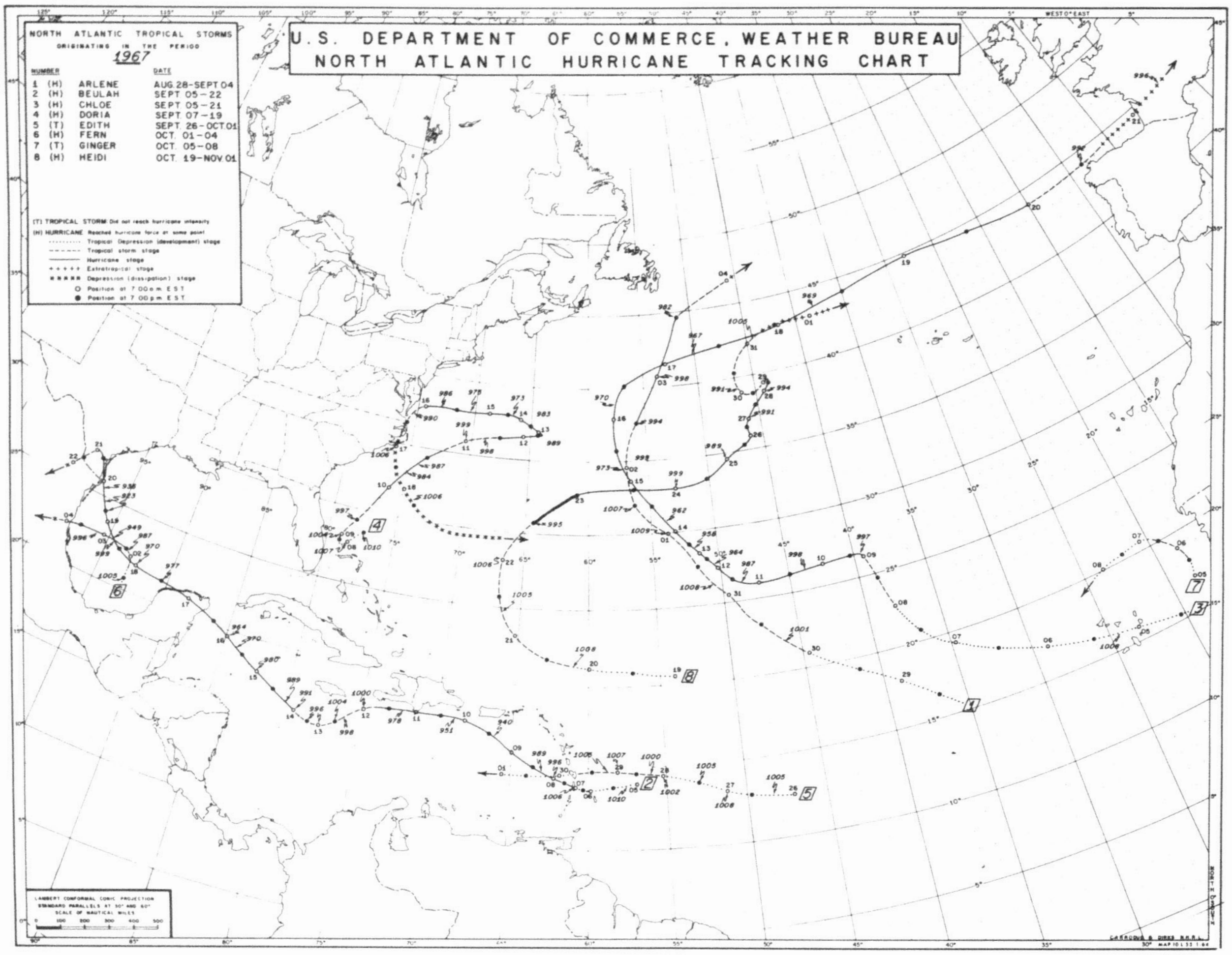

FIGURE 2.—Tracks of named hurricanes and tropical storms, North Atlantic, 1967.

TABLE 3.—*Damage in United States and Canada (in millions of dollars) from a few selected hurricanes*

Hurricane	Damage $10^6	Hurricane	Damage $10^6
Betsy 1965	1,419.8	Cleo 1964	128.5
Diane 1955	800.0	Hilda 1964	125.0
Carla 1961	400.0	Florida 1926	111.8
New England 1938	387.1	Isbell 1964	10.0
Donna 1960	386.5	Alma 1966	10.0
Hazel 1954	251.6	Keys 1935	6.0
Dora 1964	250.0	Inez 1966	5.0
Beulah 1967	200.0	Ginny 1963	*0.4
Audrey 1957	150.0		

*Loss more than offset by beneficial rains.

are shown in figure 2. Estimated damage figures are tabulated in table 2. A tropical depression has been added to the list since it was the most important one of the season. Damages from Beulah were not nearly so large as first estimated. Actually the $200-million figure is not far from the average dollar damage of all hurricanes making landfall in the United States. Beulah ranks eight in this respect and table 3 is an updating of the tabulation prepared by Sugg [7].

Considering that the first-named cyclone began August 28 and that there was a great hurricane which ranks with the greatest in intensity, numbei of associated tornadoes, and rainfall amounts, one might say that this was the "late and great hurricane season of 1967."

2. INDIVIDUAL CASES

TROPICAL DEPRESSION, JUNE 14–19

Satellite pictures and ship data were sufficient to observe and track the weak tropical depression which formed northeast of the Bahamas on June 14. By the 17th, it was possible to track the center on the WSR-57 radar at Charleston, S.C., and later that day, a Navy reconnaissance plane located the center of circulation. The depression entered the North Carolina coast southwest of Wilmington during the evening of the 17th, drifted northward during the 18th, and was overtaken by a cold front later the same day. It was not clearly defined on the Wilmington radar. From the remnants, there developed a frontal wave which moved east-northeastward into the Atlantic.

While there was fairly good inflow in the low levels and wind speed did approach tropical storm force at times, other conditions were not favorable for intensification. Outflow at high levels was virtually nonexistent and the air mass was really too cold to be transformed in such a relatively short time. The release of latent heat from the heavy rainfall was probably much too local to have been important. The lowest sea level pressure recorded at any land station was 1010 mb. (29.81 in.). This occurred at Charleston, S.C. A similar pressure was reported by the aircraft.

Damage was confined to the area between Myrtle Beach, S.C., and Shallotte, N.C., and was estimated to be $15,000. This was the result of some flooding and the destruction of crops caused by tides ranging up to 2.5 ft. above normal and by heavy rains. Rainfall amounts ranged up to 7.61 in. at Myrtle Beach and 7.65 in. at Ocean Drive Beach, S.C. Rains were beneficial farther north in the Mid-Atlantic States.

HURRICANE ARLENE, AUGUST 28–SEPTEMBER 4

During the latter part of August, satellite photographs revealed that the Intertropical Convergence Zone (ITC) had become more active after remaining quiescent and somewhat farther south than normal until that time. During the period from August 24 to September 3, a series of four rather well-defined cloud masses were observed to move westward off the African coast along the ITC. The first of these later formed Arlene, the second was to become Beulah, the third failed to develop further, and the fourth subsequently produced Chloe. Thus the season's first three hurricanes were spawned in rapid succession in the previously unproductive ITC.

As the first disturbance moved westward off the African coast on August 24, the upper air sounding at Dakar, Senegal, showed a windshift from northeast to southeast late on the 24th in the lower levels of the troposphere. During the following 24 to 36 hr., 3- to 4-mb. 24-hr. pressure falls were observed in the Cape Verde Islands.

Around 1800 GMT on the 25th a Pan American Airways flight reported "cyclonic circulation apparent with falling pressures between lat. 10°N. to 14°N. and long. 20°W. to 25°W." At the same time the British ship *Ripon* reported a west-southwest wind of 29 m.p.h. and heavy intermittent rain to the southwest of this area.

ESSA 5 Digitized Mosaics on the 25th, 26th, and 27th showed the disturbance continuing generally westward about 10 to 15 m.p.h. Little additional information was received in the vicinity of the disturbance during these days. On August 28 around 1800 GMT the ESSA 3 and ESSA 5 satellites showed a well-organized area of clouds and weather near lat. 16°N., long. 36°W. This was chosen as the starting point for the official track of Arlene (fig. 2). On this day the disturbance was first classified a strong tropical depression under the Satellite Classification System of the National Environmental Satellite Center. Once the strong tropical depression had formed, it moved northwestward about 17 m.p.h. Late on the 29th, the Norwegian ship *Thorsriver* reported an east wind of 46 m.p.h. near lat. 21°N. and long. 20°W. Another ship, the American *Mormacdraco* reported a 45-m.p.h. wind early on the 30th, and the first advisory on tropical storm Arlene was issued at 0800 EST on the 30th.

Navy reconnaissance aircraft reached Arlene on the afternoon of the 30th and found maximum winds of 70 m.p.h. near the center of the storm. Little change in intensity, as determined by Navy and Air Force reconnaissance, or course occurred through the late afternoon of September 1 with Arlene continuing northwestward about 17 m.p.h. with only minor variations. During this period minimum sea level pressure varied between 1001 mb. (29.56 in.) and 1009 mb. (29.80 in.). Although the central pressure was relatively high, it would appear that the observed maximum winds were produced by the strong high pressure ridge in which Arlene was embedded. This high pressure ridge also built strongly southward to the rear of the storm and apparently maintained the latter on a northwestward course into a relatively strong surface-to-500-mb. ridge. Lack of intensification can be attributed to the fact that Arlene was crossing the mid-Atlantic upper tropospheric trough.

During the evening of September 1, Arlene began to recurve sharply and accelerate to the north as the storm came under the influence of a 500-mb. trough in the westerlies moving eastward from the northeastern United States. Arlene continued northeastward through September 3 and during this period attained hurricane force. Being a minimal hurricane, Arlene probably achieved hurricane intensity at times when only tropical storm status is indicated on the track, and vice versa (fig. 2).

The minimum sea level pressure of 982 mb. (29.00 in.) and maximum surface wind of southwesterly 86 m.p.h. were recorded by Navy reconnaissance aircraft at 1700 EST on the 3d. The ESSA 5 Mosaic for approximately the same time clearly showed a break in the frontal cloudiness just west of Arlene with inflow into the southwestern quadrant of the storm.

Arlene was absorbed into a warm frontal system during the next 12 hr., filled rapidly, and decelerated appreciably. Although strong westerlies at 500 mb. were over the storm, it became a weak frontal wave which had moved only 350 mi. in the next 48 hr. Such slow movement, even as a frontal wave, may be attributable to a blocking pattern at higher latitudes with the long wave ridge position approximately in the area of deceleration. The shallowness of the storm may also have been a factor, but neither reason would appear suitable to explain a movement of less than 10 m.p.h. over that period of time.

One interesting feature of Arlene observed by APT ESSA 2 during the period August 31 through September 3 was that the convective cloud bands associated with the storm rotated almost completely around the center. Maximum winds observed by Navy and Air Force reconnaissance correlated fairly well with this feature.

No deaths or injuries were reported from shipping interests, and no warnings, other than marine, were required since Arlene remained well at sea.

HURRICANE BEULAH, SEPTEMBER 5–22

Although the 1967 hurricane season started late, Beulah ensured that it would be long remembered, especially in the minds of residents of the Rio Grande Valley where devastation of an extent previously unknown to that area was inflicted by this great storm. The disturbance from which Beulah developed emerged from the African coast on August 28, and moved westward as a "humping up" of the ITC, i.e., in the form of an "inverted vee." This configuration of cloudiness has come to be recognized from satellite photographs as a rather characteristic feature of the Atlantic ITC. With minor fluctuations this westward progression continued until September 4, when a Navy reconnaissance aircraft found a weak wind circulation. Early on September 5, ship reports verified that a weak depression had formed, with lowest pressure about 1010 mb. (29.83 in.), located near lat. 14.0°N., long. 57.0°W., at 0700 EST. Here the official track of Beulah began (fig. 2).

On September 6 the depression passed just north of Barbados and satellite photographs indicated that the circulation was becoming better organized. On September 7, a Navy reconnaissance aircraft obtained a cloud eye and a pressure center of 1006 mb. (29.70 in.) near 13.8° N., 60.5°W., at 0900 EST with maximum winds of 40 m.p.h. On that day the circulation moved into the eastern Caribbean near the southern tip of Martinique. The same afternoon an investigating aircraft measured 58 m.p.h. and 1005 mb. (29.68 in.) with the center 20 mi. off the west coast of Martinique.

The San Juan Weather Bureau issued a bulletin at 1100 EST, September 7, warning residents of the Windward Islands to expect thundershowers and squalls and advising small craft to stay in port. The first advisory on tropical storm Beulah was issued the same day at 1900 EST, placing the center 35 mi. west of Martinique.

Beulah recorded the first chapter of her long tale of death and destruction during this period. The northern Windward Islands sustained considerable water damage, either from prolonged heavy rains or tidal and wave action along the coast. Fifteen persons died on Martinique and two on St. Vincent. Heavy rains, associated with an upper trough, began as early as September 4 on Martinique and St. Lucia, setting the stage for the flooding which accompanied the torrential downpours from the storm itself. An 18-hr. rainfall of 11.85 in. was recorded on Martinique on September 8. Flooding on the two islands tremendously damaged houses, bridges, roads, and crops. The St. Lucia banana crop was 30 percent destroyed. Total damage on the island was estimated by the government at $3 million and that on Martinique was placed at $4.5 million.

Beulah rapidly strengthened and attained hurricane insensity by midday on September 8. Thus Beulah became only the third September storm of this century to gain hurricane force in the eastern Caribbean. Deepening continued as Beulah moved on a northwestward track and came under surveillance of land-based radar at San Juan. Air Force reconnaissance measured a central pressure of 940 mb. (27.75 in.) on September 9 when the hurricane was about 100 mi. south of Puerto Rico. This was the lowest pressure found during her trek through the Caribbean. Beulah now threatened Hispaniola and on the morning of September 9 a hurricane watch was advised for the Dominican Republic and Haiti, with emphasis on the south coastal areas. Gale warnings were raised for the south coast of Puerto Rico.

On September 10 radar reports indicated a more westward track as the hurricane crossed to the west of a weak trough and came under the influence of an upper anticyclone located to the northwest, over the Bahamas. Beulah thus aimed her fury at the Barahona Peninsula of the Dominican Republic, the same area ravaged by hurricane Inez just 1 yr. ago. However this time 200,000 residents evacuated the coast and only two deaths were reported, compared to a death toll of approximately 100 from Inez. No dollar estimate is available, but considerable damage to roads, bridges, and the banana and coffee crops was reported.

In Puerto Rico there was scattered damage along the south coast mainly to small craft and as the result of flooding. This was partially offset by beneficial rains, ending a period of severe drought. After skirting the Barahona Peninsula on September 11, Beulah continued westward, moving parallel to, and about 50 mi. south of the Tiburon Peninsula of Haiti, sparing that beleaguered area from the full force of her winds and inflicting relatively minor water damage.

During the period from the 10th to the 13th a remarkable weakening occurred. In this interval, the central pressure rose approximately 55 mb. (1.63 in.) and maximum winds decreased from 150 m.p.h. to only 40 m.p.h. The hurricane was downgraded to a tropical storm early on the 12th. Thus Beulah, after having initially intensified in an area usually considered unfavorable, proceeded to weaken in region generally regarded as conducive to intensification. Beulah's brush with Hispaniola probably contributed, at least initially, to her decay but it is felt that the major factor was the environmental changes in the upper troposphere. A strongly confluent jet stream to the rear of a 200-mb. trough penetrated from the mid-Atlantic southwestward over the storm, greatly impeding its outflow. This northeasterly current also served to deflect the storm from its westward course, thus eliminating any serious threat to Jamaica.

As the confluent zone aloft moved eastward and was replaced by a ridge, Beulah once again became a hurricane and turned toward the northwest. It soon became apparent that Beulah would become a large and dangerous storm and that landfall on the Yucatan Peninsula or the Gulf of Mexico coast was inevitable.

As the northwestward course became more firmly established, the threat to Cozumel Island and northeastern Yucatan increased. Residents of these areas, in the midst of Mexico's Independence Day celebration, were warned to make preparations against hurricane force winds. The advisories and bulletins issued by the Miami Weather Bureau on Saturday, September 16, stressed the need for continued vigilance in these areas as Beulah hesitated momentarily on her northwestward course. Landfall on Cozumel occurred during the evening of September 16 with maximum winds about 100 m.p.h. Forty percent of the houses on the Island, virtually all of light construction, were totally destroyed, and several hotels were severely damaged. Tourism, the major source of income on the Island, suffered heavily in Beulah's aftermath.

Beulah next took aim across sparsely populated northeastern Yucatan toward the coastal city of Progresso, where 15,000 people had been evacuated in 1966 as Inez skirted the coast. Five persons were killed in the town of Tizimim, near the north-central coast, when a clocktower was toppled by the winds. Farther west, damage was relatively minor.

Beulah entered the southwestern Gulf of Mexico on the afternoon of September 17 (fig. 1), weakened only slightly from her traverse of the Yucatan coastal lowlands. The pressure rose only 10 mb. (967 to 977 mb.) or 0.3 in. between reconnaissance measurements preceding and following the land crossing. Forecasters were thus faced with the gloomy predicament of an already substantial hurricane bounded within the limited confines of the Gulf of Mexico, and being further energized by its warm waters. A hurricane watch was issued for the Texas coast at 1100 EST, September 17.

Expectations of further intensification soon materialized as Beulah attained a lower central pressure with each succeeding measurement. The hurricane deepened to such an extent that, on the afternoon of September 19 and once again that evening, reconnaissance aircraft of the Air Force and ESSA recorded a central pressure of 923 mb. (27.25 in.), second only to the 920 mb. (27.17 in.) found in hurricane Hattie of 1961, in the history of hurricane reconnaissance.

Early on September 18 Beulah, continuing on a northwestward course, came under surveillance of the Weather Bureau radar at Brownsville. Radar reports indicated that Beulah's motion was somewhat erratic, reminiscent of the cycloidal path that hurricane Carla followed through the western Gulf of Mexico in 1961. At 0500 EST, September 19, hurricane warnings were issued for the Texas coast from Brownsville to Port Aransas and precautionary measures along the northeastern coast of Mexico were urged.

Beulah made landfall between Brownsville and the mouth of the Rio Grande about daybreak on September 20. Before the hurricane eye struck land the central pressure rose gradually and was probably a little less than 950 mb. (28.05 in.) at the time of landfall. At 0800 EST, the pressure at Brownsville fell to 951 mb. (28.07 in.), which was the lowest land station reading. The SS *Shirley Lykes*, at anchor in Port Brownsville, reported winds of 136 m.p.h. The Brownsville Weather Bureau Office recorded a peak gust of 109 m.p.h. but the anemometer shaft tilted 30°, so the actual wind was probably higher.

The center remained over land as it moved north-northwestward parallel to the lower Texas coast during the day. The storm gradually weakened but hurricane force winds occurred as far north as the Corpus Christi-Alice area during the evening of September 20. The storm stalled near Alice during the night and then arced slowly southwestward. On September 22 the circulation finally broke up in the mountainous terrain near Monterrey, Mexico.

The storm surge left dramatic evidence of its magnitude along Padre Island. A post-storm Weather Bureau-ESSA inspection team [3] surveying the Island found a total of 31 cuts completely through the Island in the portion extending south from a point 30 mi. south of Corpus Christi. At lat. 26.4°N., the storm surge was found to have reached a height of at least 18 ft. The height of the storm surge diminished southward toward Port Isbell, but a reliable high-water mark of 12 ft. m.s.l. was ascertained in a damaged house in the community of South Port Isbell (26°N.). Some maximum tide gage readings along the mainland included 7.4 ft. at Rockport, 7.0 ft. at Corpus Christi, and 5.5 ft. at Port Aransas.

Torrential rains fell in southern Texas and northeastern Mexico and produced major floods. Every river and stream in southern Texas south of San Antonio flooded. Storm rainfall amounts ranged from 10 to 20 in. over much of southern Texas, and totals exceeded 30 in. in some areas. Previous flood records were erased as the rain waters collected in the lower Texas rivers. The San Antonio crested at a record 53.4 ft. near Goliad, 18 ft. above flood stage. The Nueces reached 46 ft., exceeding the previous all-time high by 2 ft. The Lauaca crested at 26.3 ft. at Edna; flood stage is 21 ft. The Navidad at Ganado surpassed the flood level of 29 ft. by a full 10 ft.

Beulah's record-setting potential was not confined to flooding. It also spawned an unsurpassed number of tornadoes—47 in all [4]—far exceeding the previous high of 26 triggered by Carla in 1961. The tornadic activity was confined to Texas, but encompassed a vast area extending from the coast to the Big Bend. However most of the tornadoes were small, occurred in rural areas, and inflicted only minor damage. A few exceptions, however, had tragic consequences. Four persons were killed and six injured when a tornado struck near Palacios on the 20th and another claimed a fifth fatality at Louise on the same day. Damage ranging into six figures occurred at Burnet, New Braunfels, Sweet Home, and Fulton Beach.

The death toll from Beulah reached 15 in Texas, five as the result of tornadoes and 10 from flooding. South of the border, 19 people died in Mexico and 100,000 were left homeless by the flooding. A summary of meteorological data associated with Beulah in Texas is given in table 4.

HURRICANE CHLOE, SEPTEMBER 5–21

As the fourth in the series of disturbances moved off the African Coast on September 4, Dakar reported winds shifting from northeast to southeast in the layer extending from the surface to 700 mb. The next day, the Low passed through the Cape Verde Islands (fig. 2) with a minimum pressure of 1008 mb. (29.76 in.) and 25- to 30-m.p.h. winds. On the 7th, the depression turned northwestward under the influence of a rather vigorous middle-latitude trough. However, the trough filled and moved eastward without picking up Chloe. Slowly intensifying during the northward motion, Chloe attained tropical storm strength on the 8th. The next day, an Air Force reconnaissance plane reported 86-m.p.h. winds and a central pressure of 997 mb. (29.44 in.). Failing to make contact with the trough, hurricane Chloe turned sharply westward.

Low pressure off the eastern United States coast associated with Doria provided a southerly steering current which began influencing Chloe by September 11. The hurricane deepened again as it took on a northward component of motion. The minimum central pressure reported in Chloe was 958 mb. (28.29 in.) on September 13.

[3] R. H. Simpson, H. E. Foltz, and L. L. Means.

[4] This figure represents the best minimum estimate. Investigations now underway may update this figure in the future.

TABLE 4.—*Hurricane Beulah, meteorological data, September 5–22, 1967*

Station	County	Date	Pressure		Wind						Tide		Rainfall		Remarks
Texas			Lowest (in.)	Time (CST)	Fastest mile (m.p.h.)	Dir.	Time (CST)	Peak gust	Dir.	Time (CST)	Highest (ft. m.s.l.)	Time (CST)	Storm total (in.)	Largest 24-hr. total (in.)	
Alice	Jim Wells	21	29.15	0100	*58	ENE	20/1900	*97	ENE	20/1915			14.84	6.65	
Aransas Pass	San Patricia	20	29.44	1700–1900	*68	SE	1920	*84	SE	1920			16.71	7.38	
Beaumont	Jefferson	20	29.85	1900	30	E	1505				3.0	1500	0.04		
Bishop	Nueces	20	28.94		83	SE	0800	94	SE				14.08	6.30	Wind data from NAAS, Kingsville
Brownsville	Cameron	20	28.07	0700				109	NE	0119			15.57	*12.09	Anemometer support tilted 30°
Corpus Christi	Nueces	20	29.24	1710	72	ESE	1934	86	ESE	1935	7.0	2200	14.43	6.52	
Edinburg	Hidalgo	20			*85	NW	1500	*104	NW	0800–1000			15.34	7.52	
Galveston	Galveston	20	29.80	0600	31	SE	19/2155	37	SE	1458	3.4	2230	0.01	0.01	
Houston	Harris	20	29.78	1756	28	ESE	1355	41	ESE	1355			2.80	2.46	
Karnes City	Karnes	20–21						*50	NE				19.72	7.95	
Kingsville	Kleberg	20	29.00	1758	*90	E	0900–1000	*108	E	1000–1100			11.41	4.16	
Laredo	Webb	21	29.41	0900–1100	29	N	1400–2400	53	ENE	1400			7.25	3.68	
Palacios	Matagorda	20						69	E	0559			11.55		
Pharr	Hidalgo	20	27.98	1530	*70	NW	0930–1530	*102	NW	1000–1500			21.50		
Pierce	Wharton	20	29.82	0700				*35	NE	0700			7.09	3.86	
Port O'Connor	Calhoun	20						*75	E	2100			8.85	4.85	
Premont	Jim Wells	20	28.82	1900	*85	S	1900	*100	S	21/0100			*18.00		
Raymondville	Willacy	20	28.12	1250	*115	NE&E	1100–1400	*120	NE&E	1220			16.15	8.90	
Refugio	Refugio	20	29.54										13.42	7.92	
Robstown	Nueces	20											14.22	6.38	
Rockport	Aransas	20	29.52	1430–1830	*58	E	2230–2330	*81	ESE	2230	7.4	2230	*18.38		
San Antonio	Bexar	20	28.91	1917	27	NE	1938	35		1607			5.55	2.45	
Sebastian	Willacy	20			*95	S	0500	*100		0630			*19.00	*15.00	
Victoria	Victoria	20	29.64	1645	35	E		47	E				12.97		24.05 in. downtown; 28.28 in. 10 mi. north

*Estimated values.

Approaching Doria on the 15th, Chloe turned northward. Westerlies steered the storm eastward, away from Doria, on September 17 (fig. 1). Satellite pictures suggest that Chloe remained rather intense and probably retained tropical character while crossing the North Atlantic. The last good data regarding intensity were received on September 18 from an Air Force plane that found a central pressure of 969 mb. (28.61 in.). No additional information concerning the thermodynamic nature of the storm was collected until its remnant reached Europe. When the baroclinic effects became dominant is not known. The extratropical stage may have occurred 12 to 24 hr. earlier than indicated in figure 2.

The only casualties attributed to Chloe resulted from the sinking of the *Fiete Schulze* in the Bay of Biscay on September 21. Three crewmen drowned and 11 were reported missing.

HURRICANE DORIA, SEPTEMBER 7–19

Doria was one of the most erratic storms ever observed. It moved in every possible direction at one time or another during its life (fig. 2) and, if one goes back to its beginning as a wave cyclone, it crossed over its previous track twice. Doria's intensity also was quite variable as cold or dry air entered its circulation intermittently.

Circulation was first observed around a cold frontal low pressure system off the northeast Florida coast on September 4. This Low drifted aimlessly for 3 days in a small area (radius 100 mi.) centered 250 mi. east of Jacksonville. On September 7, the lowest pressure was 1010 mb. (29.82 in.) and on the 8th 1007 mb. (29.74 in.). The center at that time was about 50 mi. north of Grand Bahama Island. Doria reached tropical storm intensity the following day about 100 mi. east of Cape Kennedy and began moving

TABLE 5.—*Hurricane Doria meteorological data September 16–17, 1967*

Station	Lowest pressure (in.)	Wind			Total rainfall (in.)
		Fastest mile (m.p.h.)	Time (EST)	Peak gust (m.p.h.)	
NEW JERSEY					
Atlantic City (WBAS)	29.84	26	16/0056	39	0.53
MARYLAND					
Ocean City				58	
Ocean City (Motel)		55		59	1.03
Salisbury		25		48	
VIRGINIA					
Wallops Island (NASA 37°51′N., 75°29′W.)	29.63	51	16/1131	60	0.66
Norfolk (WBAS)	29.60		16/1619	55	0.53
NORTH CAROLINA					
Cape Hatteras		26	16/2018		1.04
Wilmington (WBAS)	29.83	26	17/1313		1.40
DELAWARE					
Indian River Inlet		50		83	

more rapidly northeastward. A gradual warming of over 3°C. had occurred since the first circulation was observed. The upper air soundings from Cape Kennedy, Fla., show a warming of about 3°C. between 10,000 and 20,000 ft. during this period.

Doria reached hurricane intensity and passed about 100 mi. southeast of the North Carolina capes on the 10th. The following day cold air entering Doria's circulation weakened it to less than hurricane force as the center moved almost due east. Doria warmed again on the 12th as its movement slowed markedly and its winds reached hurricane force once more. High pressure at the surface and aloft over the New England area turned Doria westward and it continued as a hurricane to within a few miles of the Virginia capes on September 16. Then Doria again encountered cold and drier air and moved over colder water. These influences and that of a large portion of its circulation being over land weakened Doria rapidly as it turned southward. Hurricane warnings remained in effect because of high tides and rough seas, even though Doria no longer had hurricane force winds. It is indeed fortunate for the mid-Atlantic coastal areas that this weakening and turning southward occurred.

The weakened center reached land near the Virginia-North Carolina border and continued southward across the North Carolina capes and back to sea on September 17 (fig. 1). Doria continued southward and then eastward as a weak depression but was still recognizable 4 days later south of Bermuda (fig. 2).

Doria attained her lowest central pressure, 973 mb. (28. 73 in.), well at sea, about midway between Nantucket and Bermuda, on September 14. The highest measured wind, 114 m.p.h., was recorded by the ship, *Esso New Orleans*, at midnight on the 15th. The highest wind reported by a land station near the center was 50 m.p.h. with gusts to 83 m.p.h. at Indian River Inlet, Del. The highest tide, 6.5 ft. above normal, also occurred there. A summary of meteorological data from stations near Doria's path is given in table 5.

Only minor damage occurred along the coast from New Jersey to North Carolina. Doria claimed three lives when a small boat sank in high seas off Ocean City, N.J.

TROPICAL STORM EDITH, SEPTEMBER 26–OCTOBER 1

Tropical storm Edith originated on the intertropical convergence zone. The disturbance was initially noted very near the African Coast on the satellite pictures of September 20. Successive pictures showed that this disturbance moved westward 5° to 6° of long. per day. But it was not until September 26 that sufficient circulation features, established by ships and by satellite and aircraft reconnaissance, justified the upgrading of the disturbance to a tropical depression (fig. 2). Possibly Edith vacillated between depression and storm intensity during the next 2 days, but the track was not drawn for storm intensity until the 28th. This decision was based mainly upon the lowest pressure, 1000 mb. (29.53 in.), and highest winds, 55 m.p.h., measured during Edith's life history.

The reason for the weakening and dissipation of the storm is not known. But two contributing factors may have been 1) the westward movement of Edith under a cold upper trough and 2) the release of latent heat at a location too far from the surface minimum pressure. The latter feature is suggested by satellite pictures which show a large overcast area situated well to the east of the center of circulation.

Edith moved through the Northern Windward Islands during the morning of the 30th; the center had become enlarged and elongated. There were no sustained strong winds reported in the Island Chain, although gustiness was noted, especially around Martinique and Guadeloupe. Some local flooding might have occurred, but damage should be considered minor. No deaths were reported.

HURRICANE FERN, OCTOBER 1–4

During the latter part of September, a cold front swept through the southwestern Gulf of Mexico and Bay of Campeche. On September 29 Carmen, Mexico, reported northwesterly gusts over 60 m.p.h. as the front passed. By the 30th, pressures were falling in the Bay of Campeche and satellite pictures on the morning of October 1 indicated a large circulatory cloud mass centered near 20°N., 93°W.

The satellite pictures on the morning of October 2 showed that the system had become better organized. Navy reconnaissance aircraft that afternoon located Fern's center about 300 mi. east of Tampico, Mexico. On the same day the British ship *Plainsman* encountered storm force winds, 1004-mb. (29.65 in.) pressure, and a pressure drop of 10 mb. (0.30 in.) in 16 hr.

The northward movement of the depression (fig. 2) was not a result of steering currents, but of intensification processes. After rapidly attaining hurricane intensity, with peak winds about 85 m.p.h., and central pressure of 987 mb. (29.15 in.), the storm moved slowly westward to west-northwestward about 7 m.p.h. and turned west-southwestward as it neared the coast. The center moved inland about 30 mi. north of Tampico early on the 4th. This storm dissipated rapidly over land. Fern was of maximum intensity at the time it was first located but weakened slowly and remained a very small storm as it moved through the southwestern Gulf of Mexico. When the center crossed the coast the highest winds were probably slightly less than hurricane force.

The weakening of Fern in an area where storms seldom lose intensity was probably the result of two contributing factors: 1) cooler sea water undoubtedly left in the wake of severe hurricane Beulah, which moved through the area 2 weeks earlier, and 2) a strong outbreak of cold air, mentioned above, also following Beulah. Thus the available air flowing into the circulation was of modified tropical origin.

No forecast problems arose with Fern as a moderately strong ridge of high pressure at the surface and aloft over the northern Gulf of Mexico held firmly during the next 2 days and thus steered the storm westward.

Although the rainfall accompanying Fern as it moved inland was not excessive, it was sufficient to cause additional flooding on the Panuce River, which was swollen from the effects of Beulah. Three persons drowned in the rising waters, but only minor damage was attributed to Fern.

TROPICAL STORM GINGER, OCTOBER 5–8

Ginger formed in the wake of a tropical depression that moved off the African Coast on October 3. Although data are limited, it appears that the storm developed within an area of convection 200 to 300 mi. northeast of the depression center. Satellite pictures on October 5 and 6 showed a well marked vortical cloud character suggesting tropical storm intensity (fig. 2). This was confirmed early on the 6th when three different ships reported 40- to 45-m.p.h. winds. Based on this information, Ginger was named.

The storm turned to a more westward track and rapidly weakened on the 7th. One ship near the center at 1200 GMT reported a pressure of only 1012 mb. (29.88 in.) and 10-m.p.h. winds. Satellite pictures on this same day verified the weakening trend. The reason for weakening is unknown. The remains of Ginger could still be detected on satellite pictures on the 8th. However, 24 hr. later all evidence of circulation had dissappeared.

In summary, Ginger was a minimal tropical storm for no more than 24 hr.

HURRICANE HEIDI, OCTOBER 19–NOVEMBER 1, 1967

Heidi appeared, in embryonic form, as a cloud mass revealed by satellite photographs in the tropical central Atlantic in mid-October. From this area of convective activity a depression formed about 500 mi. northeast of the Lesser Antilles on October 19, and it is at this point that the official track of Heidi began (fig. 2).

The SS *Sunrana* passed through the depression on October 20 and found winds of 58 m.p.h. in squalls and lowest pressure of 1008 mb. (29.76 in.). Although the winds were of tropical storm intensity, the system did not appear to have a warm core, and its designation as a named storm was withheld pending receipt of additional data.

A Navy investigative flight was dispatched on October 21, and maximum winds of only 35 m.p.h. and minimum pressure of 1005 mb. (29.68 in.) were measured. A weak wind circulation was found but no eye was visible on radar. The system was located on the edge of a strong baroclinic zone to the northeast, with very little surface pressure gradient on the west side. The SS *Homeric*, passing a short distance east of the center early on October 22, found winds of 70 m.p.h. in squalls, but on the west side no wind of over 25 m.p.h. was reported. The thermal character of the system remained in doubt until an Air Force reconnaissance flight later in the day found that the center had warmed 2°C. through the middle levels. A short time later a Navy aircraft reported that rapid deepening had occurred, with the central pressure falling to 995 mb. (29.38 in.). Heidi was upgraded to hurricane status in the midnight advisory issued by the Miami Weather Bureau. At this time Heidi was recurving into a trough in the westerlies, and the hurricane proceeded on an east-northeastward course about 20 m.p.h. for the next 2 days, while maintaining minimal hurricane intensity.

On October 25 the westerlies weakened and retreated northward as a strong upper ridge built from Nova Scotia to Bermuda. The hurricane was thus embedded in an environment of light and variable winds at upper levels, while at the surface, high pressure, extending from the east around through the north and northwest, impeded appreciable northward movement. The hurricane's path thus became essentially blocked, and for the next 5 days, from October 25 to 30, Heidi wandered mainly northward about 5 m.p.h. Minimum pressure of 981 mb. (29.00 in.) was attained on October 26, while maximum surface winds of 115 m.p.h. were found on the previous day.

This slow northward movement permitted progressively cooler air and water to weaken Heidi to tropical storm intensity on October 29. By the 30th the storm had lost its tropical characteristics and turned eastward as a low pressure area. Finally, on November 1, ship and satellite data indicated that the remnants of Heidi had become absorbed into the broad-scale features of the North Atlantic.

Heidi posed no serious threat to any land areas and was of interest mainly to shipping. No reports of casualties of damage attributable to the hurricane were received.

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